How the United States Can Harmonize Its Internal Conflict Over the Nuclear Fuel Cycle

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Abstract

This paper examines the underlying reasons for the current impasse existing in the U.S. regarding nuclear fuel cycle policy, and proposes actions to shift U.S. fuel cycle policy to meet both non-proliferation and domestic energy security concerns. Three near term actions are suggested: (1) a program to convert weapons plutonium to MOX fuel for consumption in existing water reactors; (2) reexamination of the safety and fissile material security of the direct disposal option; and (3) a program to encourage dry recycle of spent fuel into existing water reactors, without separation of fissile materials from the fission products.

Introduction

As the largest producer of nuclear electricity in the world, and as the country which originally brought both the energy and weapons potential of uranium and plutonium to the world scene, the United States has a responsibility to provide leadership in applying this energy source safely and carefully to meet both the energy needs and environmental needs of its citizens, while at the same time assuring that it is not used by others for weapons purposes.

In the last twenty years, it has not exercised this leadership. Since its turn away from a closed nuclear fuel cycle to a direct disposal approach, in the mid 1970's the U.S. has become increasingly impotent in its ability to influence the use of nuclear energy in the rest of the world. The growing independence of States in sensitive regions of the world with respect to nuclear energy is evident. Of even greater concern, under the present course of direct disposal, the U.S. appears to be foreclosing the continued use of this environmentally benign energy source to future Americans.

Polarization of Fuel Cycle Views in the U.S.

The debate over the proper course for the U.S. nuclear fuel cycle has become increasingly polarized. This polarization stands in the way of any lasting resolution

of the conflict. Both sides defend their position with religious fervor. A compromise is necessary if we are to have a chance of solving this problem.

The authors believe that a compromise is possible. However, to change course is not easy, especially when the subject is a national policy having both international and domestic energy security implications. Therefore, we believe the proper immediate action is to take actions to allow the U.S. to PAUSE while it examines the future direction that best meets the needs of both sides. The Interim Storage Facility mandated in pending legislation is exactly the kind of action that allows such a pause.

The main object of this paper is then to show how such a PAUSE can indeed lead to harmonization of the polarized views, and a future course which solves both the international non-proliferation as well as the domestic energy security issues.

The Current Approach: The Direct Disposal Fuel Cycle

Our present course remains one which treats spent fuel, including both its fissile and its fertile content, as a waste, to be eventually disposed of directly in a geologic repository. Neither the utility industry, nor the Federal Government have any existing infrastructure, or ongoing development plans, to recycle this fuel or otherwise process it, prior to disposal. The arguments for those who favor continuation of this course, and those who oppose it, are summarized as follows:

The NP's (No Plutonium)—Those who favor continuation of the present course, base their arguments on:

- The economics of reprocessing is unfavorable. The cost of recycling in Fast Breeder reactors remains prohibitively high.

- Reprocessing creates large quantities of liquid radioactive wastes which must be treated and disposed of. It also adds to the radiation exposure of workers.

- There's plenty of uranium, much at low cost, to sustain nuclear energy for many decades. By mid-century, there may be other sustainable energy sources besides nuclear.

- It's best not to separate plutonium from the uranium and fission products; it's too easy to divert to weapons use.

- Fuel pools are filling up. It's important to transport the spent fuel to interim storage and concentrate on getting the U.S. repository designed, licensed and in operation. We can wait till later to consider reprocessing and recycle. Meanwhile, if use of nuclear power is to survive in the U.S.,

we must show the public that we can follow through with our program of direct disposal.

The RC's (Recycle Spent Fuel)—Those who favor a return to the early seventies, in which U.S. policy, and industry infrastructure, were both aimed at closing the fuel cycle, reprocessing, using MOX fuel in water reactors, and continuing development of the fast breeder reactor. The RC's argue:

- Economics of reprocessing is a matter of supply and demand. When uranium demand exceeds supply, reprocessing will become economic compared to alternatives. Timing is a commercial matter and not to be prescribed in a free market.

- The ultimate safety of nuclear waste disposal will be enhanced by reprocessing, since the more hazardous wastes can be separated and immobilized in a more secure manner. Transmutation is also possible.

- Nuclear remains the only long term solution that can meet our domestic (and worldwide) energy needs without the potential for unacceptable damage to the biosphere. Only recycle will permit use of nuclear in the long run since supply constraints will eventually prevent the continued use of uranium on the once through cycle.

- Plutonium can be protected against diversion for weapons programs, provided:

  - We strengthen the IAEA safeguards regime so signatory countries cannot cheat.

  - We maintain an effective multilateral nuclear export control regime requiring full scope safeguards as a condition for nuclear export.

  - Continued progress in resolving regional conflicts allows the non-signatory countries to join the NPT.

  - Weapons states make real progress in further disarmament, and in particular begin to demilitarize dismantled nuclear weapons including plutonium.

- Unless the U.S. allows the non-nuclear weapons states access and help in peaceful nuclear technology, and in particular allows freedom of choice with respect to recycle of their spent nuclear fuel, they will seek other partners for nuclear cooperation and recycle anyway. In Asia, other partners would include Japan and China, both of whom have capability for reprocessing and supporting recycle programs in other Asian countries.

Our Current Failure to Search for a Middle Ground

The authors believe that these two sides (the NP's and the RC's) are becoming so entrenched in their positions that there is no real search for a middle ground. The NP's see no real reason to compromise; after all the current U.S. course is consistent with their position. Never mind that it has not succeeded in changing the situation overseas. Never mind that the safety and security of permanent geologic disposal of large quantities of plutonium and fission products has come into question.

The RCs are equally entrenched in their position. Anyone who talks of compromise, and alternative fuel cycle futures other than complete reprocessing, is considered a traitor.

It is not too late to find a common position. By striving for a common position, both sides can come much closer to achieving their objectives than is possible if each side sticks to its present course.

Why the NP's Lose If We Stick to Our Present Course

The evolution of the world wide non-proliferation regime, with increasing dependence on using the energy value of plutonium, provides direct evidence that under its present course, the U.S. will become increasingly impotent in effecting world use of plutonium. Let us take a brief look at that history. The evolution of U.S. international policy towards the peaceful use of nuclear energy can be viewed in five distinct periods, starting with a "secrecy" period immediately after World War II, arriving at the worldwide accumulation of plutonium stage which exists today. The following briefly characterizes each of these phases:

1. Secrecy (1946-1953): Recognizing the enormous destructive force of the atom bomb, the victorious Allies agreed that international controls would have to be put into place before information related to peaceful applications of atomic energy could be transferred. In June 1946, the U.S. presented the Baruch Plan, a daring but ill-fated proposal that called for the transfer of all potentially-dangerous atomic energy activities to a new international authority, followed by the destruction of all existing nuclear weapons. As mandated by the Atomic Energy Act of 1946, the U.S. closed down its wartime collaboration with the UK and Canada and pursued a policy of secrecy and denial.[1]

2. Promotion of Peaceful Atomic Energy, under Safeguards (1953-1974): By 1953, it was clear that the efforts to shroud the technology of nuclear fission in secrecy was failing. The USSR and the UK had successfully tested nuclear explosive devices, and American firms were being held back from competing in the incipient market for nuclear power technology. President Eisenhower's "Atoms for Peace" address in December 1953 signaled the start of a new era of nuclear cooperation and institution-building. Bilateral nuclear cooperation agreements were concluded with

developing as well as industrialized countries. Safeguards agreements were negotiated to assure that nuclear materials and technology being transferred could not be diverted to weapons use.

Many technical approaches to nuclear power generation were being explored and developed. Underlying this activity was a common understanding of how the nuclear fuel cycle would evolve. Although the first generation of nuclear power reactors would be based upon uranium, it was widely feared that exploitable uranium deposits would be quickly depleted. Believing that the next generation of reactors would be increasingly based upon plutonium, many countries began to investigate reprocessing and recycle technologies.

After France (1960) and China (1964) joined the "nuclear club" and concern deepened over the prospects of further nuclear proliferation, the U.S. gave its support to the establishment of a strong nonproliferation regime based on the Nuclear Non-Proliferation Treaty (NPT). The negotiations leading to the NPT, which entered into force for a 25 year term in 1970, reflected not only the widespread desire to prevent further proliferation. A second basic and complementary objective was to establish a firm legal underpinning for the right of all Parties to the NPT to develop and use nuclear energy for peaceful purposes. This second objective was of critical importance to the industrialized Non-Nuclear Weapons States which were developing nuclear power programs. Germany, for example, emphasized that no nuclear activities for peaceful purposes could be prohibited. U. S. negotiators accepted this interpretation, and agreed that neither uranium enrichment nor the development, under safeguards, of plutonium-fueled power reactors would violate the NPT.[2]

3. Controls over Sensitive Technologies Tightened, as Proliferation Concerns Deepen (1974-1981): Following India's peaceful nuclear test in 1974, the U.S. responded with a series of initiatives to strengthen the international nonproliferation regime. The first steps were taken to persuade the other principal nuclear suppliers to establish a voluntary set of guidelines on the terms and conditions for nuclear trade, and to place barriers on exports of sensitive technologies and facilities. Publicly-funded R&D programs supporting the development of reprocessing and breeder reactors came under attack in the Congress. The Ford Administration undertook a major review of U.S. nuclear energy and nonproliferation policies, which led to a decision to slow down the production of separated plutonium until an effective international regime of safeguards and nuclear export controls was in place.

The tentative steps taken by the Ford Administration to ease back on fuel recycling programs were pursued with far more force by President Carter. The NRC was persuaded to halt a nearly-completed study evaluating the licensability of reprocessing (GESMO - Generic Environmental Statement on the Use of Recycled Plutonium and Mixed Oxide Fuel in Light Water Cooled Reactors). The fast breeder prototype reactor program was canceled, and construction of a commercial

reprocessing plant in Barnwell, South Carolina, was brought to a halt. This shift in U.S. policy was made clear in President Carter's opening remarks at the organizing conference for INFCE (International Fuel Cycle Evaluation) in October 1977:

"I have the feeling that the need for atomic power itself for peaceful uses has perhaps been greatly exaggerated. And I hope that all nations represented here and others will assess alternatives to turning to this source of power . . ."[3]

4. Carrots and Sticks (1981-1992): Under President Reagan, U.S. policy moved from a stance of prohibiting fuel recycling to that of encouraging the once-through fuel cycle. The Nuclear Waste Policy Act of 1982 committed the Federal Government to build a permanent geologic depository for spent fuel and to accept spent fuel from U.S. utilities starting 1998, thereby relieving them of the responsibility for the back end of the fuel cycle. Programs looking to the eventual use of plutonium fuel were no longer prohibited. The Department of Energy continued the breeder reactor R&D program on a reduced scale. The U.S. ceased its efforts to dissuade other advanced nuclear countries to abandon their fuel recycling programs. In a move that came under considerable fire, the U.S. assisted Japan to establish a secure passage for the return of plutonium from spent fuel reprocessed by France, for use in making MOX to fuel Japanese reactors.

The Reagan and Bush Administrations also took steps to close what were regarded as weak areas in the international nonproliferation regime. Key nuclear threshold states (Argentina, Brazil, South Africa), were brought into the NPT as were the two remaining Nuclear Weapons States (China and France). By offering research cooperation combined with threats to stop furnishing HEU fuel, the U.S. sought to persuade other countries to convert their research reactors to LEU. Under U.S. prodding, the Nuclear Suppliers Group agreed to control exports of nuclear technology, and, in fulfilling a long-standing U.S. objective, to accept full scope safeguards as a condition of supply.

5. Plutonium Accumulation (Civil and Military) Grows Rapidly (1993–): The Clinton Administration has pursued the contradictory goals of reducing both the use and the accumulation of plutonium. In announcing U.S. nonproliferation and export control policy in September 1993, President Clinton said that the U.S. would seek to eliminate where possible the accumulation of stockpiles of HEU and plutonium and that it would explore means to limit the stockpiling of plutonium from civil programs. He also said that the U.S. would propose a multilateral cut-off convention on production of HEU or plutonium for nuclear explosive purposes, and that the U.S. would initiate a comprehensive review of long-term options for plutonium disposition. President Clinton made clear that the U.S. did not encourage the civil use of plutonium, but he also affirmed that the U.S. would maintain its existing commitments regarding the use of plutonium in civil nuclear programs in Western Europe and Japan.

Other policy actions were taken to reinforce the once-through fuel cycle. Funding for the fast breeder development program was eliminated. At the same time, the timetable for achieving the once-through fuel cycle was being undercut by the prospect of further delays in characterizing Yucca Mountain, Nevada as a possible permanent geologic repository.

What Has U.S. Policy Achieved?

Despite the many shifts in U.S. nuclear policy and programs, U.S. presidents have been steadfast in regarding the prevention of further proliferation as their over-riding goal. The U.S. took the lead in international efforts to set up an international structure of agreements and institutions centering upon the NPT and the IAEA, which has sharply constrained the proliferation of nuclear weapons while also providing a base for peaceful cooperation in use of nuclear energy. More recently, institutional and technological means for dealing with renegade states, in particular Iraq and North Korea, has been made more effective.

The durability and effectiveness of this structure over the long-term depends upon the dovetailing of interests of the countries involved. A commonalty of interests among countries with advanced nuclear programs underlies the cooperative programs (e.g., the Nuclear Suppliers Group) to control the export of nuclear weapons material and technology as well as in dealing with emerging threats such as the risk of smuggling of nuclear material from the CIS region.

In addition to forging a cooperative institutional and legal framework, the U.S. has worked very hard, following India's nuclear test, to suppress the use of sensitive nuclear materials and technologies. While other advanced nuclear countries have joined the U.S. to control the export of sensitive materials and technologies, they have seen no reason to place their nuclear energy policies in conformity with that of the U.S.[4] They have pointed to their treaty right, clearly established by the NPT, to the development and use of nuclear energy. Despite U.S. pressure, many EURATOM countries including France, the UK, and Switzerland, continue to rely on reprocessing as an integral part of their nuclear fuel cycle programs. Japan is exploring plans to form a common nuclear energy community with other Asian countries, called ASIATOM, in which Japan may offer fuel recycling services on a regional basis.[5] Although President Clinton has declared that the U.S. will maintain its existing commitments regarding the use of plutonium in civil programs, uncertainty over the future course of U.S. policy has often hindered nuclear cooperation with these countries.

While not halting the reprocessing programs of other advanced nuclear countries, U.S. opposition has slowed their expansion. U.S. attitudes have also influenced the decisions of Germany and others to forego their own repressing programs. Since no country has succeeded in starting up a permanent geologic repository, the slow-down in reprocessing and recycle programs has resulted in growing stockpiles of civil plutonium worldwide.

Compounding this accumulation of civilian spent fuel, successful arms control efforts have led to the increased accumulation of weapons grade plutonium from dismantled nuclear weapons. Over 100 tonnes is expected to become available from the weapons to be dismantled by the U.S. and Russia under the START treaties. The U.S. National Academy of Sciences has called this a clear and present danger.

A New Direction for U.S. Policy: Harmonizing the NP's and RC's

The tensions resulting from the conflicting policies of the U.S. on one hand, and other advanced nuclear states on the other, threaten to weaken the commonality of interests, and of programs, to reduce proliferation risk. With Japan giving serious thought to establishing an ASIATOM, there is a more likely prospect that the advanced nuclear states will break apart into blocs—North America, Western Europe, CIS, and Asia. U.S. influence would decline further, and it would be far more difficult to advance U.S. nonproliferation goals.

It is clear that the NP's must seek a pause, and a new direction, if the U.S. is to have any influence at all on the safeguarding the worlds growing stockpiles of plutonium. If the U.S. succeeds in gaining a pause in its path towards direct disposal, as would result from enactment of pending legislation, then what action can the U.S. take to find a common ground, and make this indeed a turning point to a new direction? Here are a few suggestions on how to use this pause most effectively, and what that new direction might be.

Suggestion 1—Convert Excess Weapons Plutonium to MOX Fuel: the U.S. and Russia can both proceed expeditiously to demilitarize their excess weapons plutonium and turn it into useful MOX fuel for commercial reactors. The NP camp will have to compromise their "no plutonium" policy, but this plutonium already exists; it is not a matter of separating new plutonium. Approval of this course would help set the stage for a rational debate over the question of civil plutonium. And because of the energy produced, it would not overwhelm the budgets of the weapons states. Even more important, it would demonstrate to Non-Weapons States that they can utilize already safeguarded separations and fuel production facilities in advanced nuclear states to help them gain energy value from their spent fuel, without having to install their own separations plants.

There are many acceptable proposals on the table to achieve this MOX fuel use in the near future. What is needed is the will by Russia and the U.S. and later the other Weapons States to actually do it. An example is the Canadian proposal to convert U.S. excess weapons plutonium to CANDU MOX fuel for use in Ontario Hydro's Bruce Station within 15 to 25 years. This program can begin in four years at a relatively modest cost . . . under $100 million per year. Other proposals are also attractive. In addition to the immediate problem of disposing of the plutonium, such an action by the U.S. and Russia would set the stage for a less dangerous fuel cycle regime in many of the emerging nuclear nations such as those on the Pacific

rim. Such countries would be able to depend on the U.S, Russia and other dominant nuclear states to convert their spent fuel to MOX fuel, and then they would not be forced to develop indigenous separations capability to gain the domestic energy security they seek.

Suggestion 2—Nuclear Waste System Safety and Security: The U.S. Commercial Nuclear Industry should initiate an objective evaluation of the long term safety and security of a nuclear waste repository. They should evaluate three separate options:

> Direct disposal of spent fuel—can we really seal spent fuel in a repository with sufficient assurance that the plutonium will not be diverted for weapons use after the fission product activity has decayed to lower levels, in centuries to come? Also do we have confidence that the fission products will not leak to the biosphere prior to their decay?
>
> Separation of fission products, immobilization, and disposal in a geologic repository—How much does this reduce the risk of future theft and the risk of eventual leakage?
>
> Separation of fission products and transmutation to short-lived isotopes—How feasible is this over the long term and does it afford the basis for near term fuel cycle policy?

Whilst the Federal Government and Academia have evaluated these questions many times, it is time for a careful and thorough evaluation by the nuclear plant owners/operators themselves. They have the ultimate responsibility for the entire nuclear energy system, and therefore are in a good position to decide what's best in light of recent knowledge about the wastes and recycle. Establishment of new laws, regulations and licensing regimes should follow this initial determination by U.S. utilities of what course is best from a technical and safety point of view.

Suggestion 3—Establish a Dry Recycle Initiative in the U.S.: One possible common ground between the NP's and the RC's that should be seriously examined, and adopted if possible, is establishing a dry recycle regime in the U.S. which does not involve separation of plutonium from uranium or fission products, but still allows the recycle of spent fuel. This fuel cycle can use a proven (on a pilot scale) technology (known as AIROX or OREOX) originally developed in the U.S. in the 1960's but never commercialized.

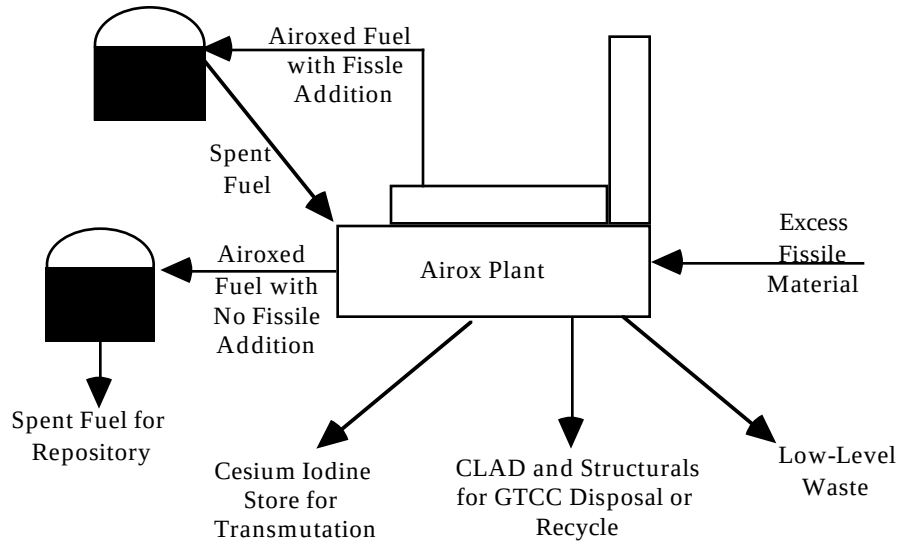
This fuel cycle approach would meet the basic goals of both RC's and NP's with only minimal compromise of their positions. It would not preclude continued use of the existing reprocessing facilities in the UK, France, and Japan, but would enable emerging nuclear nations such as South Korea, to achieve domestic energy security without separation of plutonium. In fact, it is through the initiative of the

South Korean and Canadian Nuclear establishments, with the active support of the U.S. State Department and Los Alamos scientists, that this dry recycle approach is emerging as a real technical possibility.

The Koreans call it DUPIC for DIRECT USE OF PWR SPENT FUEL IN CANDU'S. We propose to expand it to include recycle of spent fuel from LWR's back into LWR's as well as CANDU's. Such recycle requires the addition of excess fissile material, either plutonium, HEU, or when there is no longer an excess of weapons material, LEU, with enrichment of about 15% U235. The addition of fissile material will also permit multiple recycles of the oxide fuel, something that is not possible in the current DUPIC program.

A major study of this fuel cycle, as it could be applied in the U.S., was conducted by the Idaho National Engineering Lab assisted by Gamma Engineering in 1992 and reported to the Global 93 Conference.[6] That study concluded that this pilot scale technology could be demonstrated using existing LWR spent fuel, and using existing U.S. test facilities, and be ready for commercial deployment within 7 years, at a cost of $60 million. More recent work on the CANDU application is being reported by KAERI and AECL in other sessions at this conference.

The cycle is shown pictorially in the following:



By supporting the development of this fuel cycle for possible use within the U.S., both the NP's and the RC's would be opening the way for a new fuel cycle regime which is more environmentally sound than the direct disposal approach, and allows the productive use of excess fissile material derived from weapons at great monetary and environmental expense. And of greater importance, this fuel cycle can be used by non-weapons states needing a more secure peaceful nuclear future, without the proliferation hazards associated with plutonium separation. Such is the case in Korea today. If it were not for the availability of this more

safeguardable technology, the Republic of Korea would be forced to either proceed with a wet reprocessing program (either using new domestic facilities or existing facilities overseas) or in the absence of a site for spent fuel repository, slowdown their use of nuclear energy. Neither of these outcomes is in the U.S. or Korean national interest.

It is true that a definitive answer has not been developed regarding the economics of the DUPIC fuel cycle whether applied to recycle into CANDU's or into LWR's. Those currently involved in PUREX wet reprocessing will undoubtedly claim that DUPIC is more expensive, because of the need to fabricate new fuel remotely in hot cells. However, this may not turn out to be the case. In fact, because it does not depend on the use of wet chemicals, the DUPIC fuel cycle may actually turn out to be more economic than PUREX, at least while the world has large excesses of separated fissile materials. There are other dry recycle technologies that do not involve separation of fissile materials, including the pyrometallurgical system developed in the U.S. Actinide Burner Liquid Metal Reactor program. However, the DUPIC program has merit on its own right because it is the only technology which is based on existing proven water reactor technology, and therefore can be deployed in the near term. These other systems may have value for the long term, particularly in view of the high neutron economy of a fast reactor system but they do not solve the near term problem.

We believe that the only way to overcome the present impasse between the NP's and the RC's is to turn to a safeguardable recycle program that can be deployed in the near term, such as DUPIC or DUPIL. Such a course is a prerequisite, if the U.S. is to have a secure energy future domestically, and remain a player on the world non-proliferation scene.

References

1. See Lawrence Scheinman, *The International Atomic Energy Agency and World Nuclear Order* (Washington, DC/Resources for the Future, 1987), for an overview of the evolution of the NPT regime.
2. Ibid, pp 28-29
3. *Report on European Reactions to the International Nuclear Fuel Cycle Evaluation*, prepared by the Congressional Research Service for the Subcommittee on Energy, Nuclear Proliferation, and Government Processes of the Committee on Governmental Affairs, United States Senate, August 1982, p. 5.
4. The Carter Administration's campaign to stop other advanced nuclear states from continuing their fuel recycling programs was viewed as an unilateral reinterpretation of the NPT, and was not well received. See Ryukichi Imai, "Post Cold-War Nuclear Nonproliferation and Japan," a paper presented to the U.S.-Japan Study Group on Arms Control and Non-Proliferation after the Cold War and published in The United States, Japan, and *The Future of Nuclear*

Weapons (Washington, DC/The Carnegie Endowment for International Peace, 1995), pp 127-8.
5. Ryukichi Imai, "Fifty Years after Hiroshima: A Half Century of Nuclear Energy and Beyond," a paper prepared for the July 1995 Pugwash Hiroshima Conference (Tokyo/Institute for International Policy Studies, 1995), p 19.
6. Feinroth, H., et al., September 12-17, 1993. "An Overview of the AIROX Process and Its Potential for Nuclear Fuel Recycle," *Proc. Int. Conf. Future Nuclear Systems: Emerging Fuel Cycles and Waste Disposal Options: Global 93*. Seattle Washington, American Nuclear Society, La Grange Park, Illinois.